IB chemistry HL mark schemes end of year exams 2012

paper 1

1	B	11	A	21	C	31	B
2	D	12	A	22	A	32	B
3	D	13	C	23	C	33	C
4	D	14	A	24	C	34	C
5	B	15	B	25	D	35	D
6	B	16	C	26	D	36	A
7	C	17	A	27	A	37	D
8	C	18	A	28	B	38	D
9	D	19	D	29	A	39	C
10	B	20	B	30	D	40	A

paper 2

1. (a) $(\Delta H^{\ominus} = \Sigma \Delta H_{\text{f products}}^{\ominus} - \Sigma \Delta H_{\text{f reactants}}^{\ominus})$

$\Delta H_c^{\ominus} = (2\times -242 + -394) - (-239)$ (kJ mol^{-1});

$\Delta H_c^{\ominus} = -639$ (kJ mol^{-1}); *[2]*

Award [2] for correct final answer.
Do not award M2 if M1 incorrect.

(b) (i) m(methanol) = (80.557 – 80.034) = 0.523 (g);

$n(\text{methanol}) = \left(\frac{0.523 \text{ g}}{32.05 \text{ g mol}^{-1}}\right) = 0.0163$ (mol); *[2]*

Award [2] for correct final answer.

(ii) ΔT = (26.4 – 21.5) = 4.9 (K);

$q = (mc\Delta T =)\ 20.000\times 4.18\times 4.9$ (J) / $20.000\times 4.18\times 4.9\times 10^{-3}$ (kJ);

0.41 (kJ); *[3]*

Award [3] for correct final answer.

(iii) $\Delta H_c^{\ominus} = -\frac{0.41 \text{ (kJ)}}{0.0163 \text{ (mol)}} / -25153$ (J mol^{-1});

= –25 (kJ mol^{-1}); *[2]*

Award [2] for correct final answer.
Award [1] for (+)25 (kJ mol^{-1}).

(c) (i) not at standard conditions/1 atm **and** 298 K/25 °C / ΔH_{vap} for water; *[1]*

(ii) not all heat produced transferred to water / heat lost to surroundings/environment / *OWTTE* / incomplete combustion (of methanol) / water forms as $H_2O(l)$ instead of $H_2O(g)$; *[1]*

Do not allow just "heat lost".

(d) $\Delta S^{\ominus} (= \sum S^{\ominus}_{products} - \sum S^{\ominus}_{reactants}) = 2\times 189 + 214 - (240 + 1.5\times 205)$;
$= 44.5 \text{ J K}^{-1} \text{ mol}^{-1} / 0.0445 \text{ kJ K}^{-1} \text{ mol}^{-1}$ *[2]*
Award [2] for correct final answer.
Do not award M2 if M1 incorrect.

(e) temperature of 298 K;
$\Delta G_c^{\ominus} = (\Delta H_c^{\ominus} - T\Delta S_c^{\ominus} =) -726 - 298\times 44.5\times 10^{-3} \text{ (kJ mol}^{-1}) /$
$-726000 - 298\times 44.5 \text{ (J mol}^{-1})$;
$= -739 \text{ kJ mol}^{-1} / -7.39\times 10^5 \text{ J mol}^{-1}$; *[3]*
Award [3] for correct final answer.

(f) $\Delta G_c^{\ominus}$ is always negative **and** temperature won't alter spontaneity of reaction; *[1]*

2.

(a) cobalt has a greater proportion of heavier isotopes / *OWTTE* / cobalt has greater number of neutrons; *[1]*

(b) 27 protons **and** 25 electrons; *[1]*

(c) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$ / [Ar] $3d^7$; *[1]*

(d) ^{60}Co/Co-60/cobalt-60 **and** radiotherapy/sterilization of medical supplies/radiation treatment of food sterilizations/industrial radiography/density measurements in industry/(medical/radioactive) tracer;
Allow treatment of cancer.
Do not allow "just used in medicine".

OR

^{57}Co/Co-57/cobalt-57 **and** medical tests/label for vitamin B_{12} uptake; *[1 max]*
Do not allow "just used in medicine".

3.

(a) $(K_c =) \dfrac{[CH_3OH]}{[CO][H_2]^2}$; *[1]*
Do not award mark if incorrect brackets are used or brackets are missing.

(b) (i) amount (of methanol)/product decreases / less methanol;
(forward reaction) exothermic / reverse reaction endothermic / *OWTTE*; *[2]*

(ii) amount (of methanol)/product increases / more methanol;
3 gas molecules/mol → 1 / decrease in volume / fewer gas molecules on right hand side/products / more gas molecules on left hand side/reactants; *[2]*

(c) high pressure expensive / greater cost of operating at high pressure;
lower temperature – lower (reaction) rate; *[2]*

(f) (i) *Molten sodium oxide:* conducts because of free moving/mobile ions in molten state;
Sulfur trioxide: doesn't conduct because no free moving/mobile charged particles/it has neutral molecules; **[2]**
*Award **[1 max]** for stating molten sodium oxide conducts but sulfur trioxide doesn't.*
Do not award M2 for "just sulfur trioxide does not conduct because it is molecular."

(ii) $Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$;
$SO_3(l) + H_2O(l) \rightarrow H_2SO_4(aq)$;
both solutions conduct; **[3]**
Ignore state symbols.

5.

(a) k increases with increase in T / k decreases with decrease in T; **[1]**
Do not allow answers giving just the Arrhenius equation or involving lnk relationships.

(b) gradient = $-E_a/R$;
-30000 (K) = $-E_a/R$;
Allow value in range –28800–31300 (K).

$E_a = (30000 \times 8.31 =) 2.49 \times 10^5$ J mol^{-1}/249 kJ mol^{-1}; **[3]**
Allow value in range 240–260 kJ mol^{-1}.
*Allow **[3]** for correct final answer.*

(c) $0.9 \times 0.200 = 0.180$ (mol dm^{-3});

rate = $(0.244 \times (0.180)^2 =) 7.91 \times 10^{-3}$ mol dm^{-3} s^{-1}; **[2]**
*Award **[2]** for correct final answer.*
*Award **[1 max]** for either 9.76×10^{-3} mol dm^{-3} s^{-1} or 9.76×10^{-5} mol dm^{-3} s^{-1}.*

6.

(a) vapour pressure ethoxyethane (81×10^3 Pa) > vapour pressure benzene (16×10^3 Pa) > vapour pressure water (4×10^3 Pa);
If three correct vapour pressure values related to each substance are stated alone award M1.
Allow range of 80–85$\times 10^3$ Pa, 14–18$\times 10^3$ Pa and 3–7$\times 10^3$ Pa.
Do not award mark for comparisons of just two substances.

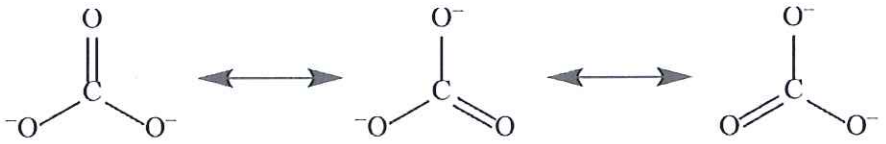
water has hydrogen bonding;
benzene has van der Waals'/London/dispersion forces;
ethoxyethane has dipole–dipole forces (and van der Waals'/London/dispersion) but they are weaker than benzene; **[4]**

(b) 81 °C; **[1]**
Allow 80–82 °C.

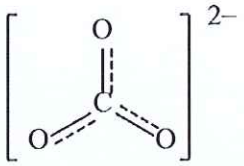
(ii) *Silicon dioxide:* strong/covalent bonds in network/giant structure/macromolecule;
Carbon dioxide: weak/van der Waals'/dispersion/London forces between molecules; *[2]*

(c) triple (covalent) bond;
one electron pair donated by oxygen to carbon atom / dative (covalent)/coordinate (covalent) bond; *[2]*
*Award **[1 max]** for representation of* C≡O .
*Award **[2]** if CO shown with dative covalent bond.*

(d) delocalization/spread of pi/π electrons over more than two nuclei;
equal bond order/strength/length / spreading charge (equally) over all three oxygens;
gives carbonate ion a greater stability/lower potential energy; *[3]*
M3 can be scored independently.
Accept suitable labelled diagrams for M1 and M2 e.g.



OR



Do not penalize missing brackets on resonance structure but 2– charge must be shown.
Allow –2 for charge on resonance structure.

(e) mixing/combining/merging of (atomic) orbitals to form new orbitals (for bonding);
Allow molecular or hybrid instead of new.
Do not allow answers such as changing shape/symmetries of atomic orbitals.

Carbon dioxide: sp;
Diamond: sp^3;
Graphite: sp^2;
Carbonate ion: sp^2; *[5]*

(d) increases rate of forward and reverse reactions (equally) / lowers activation energy/E_a (of both forward and reverse reaction equally) / provides alternative path with lower activation energy/E_a; *[1]*
Accept reactants adsorb onto the catalyst surface and bonds weaken resulting in a decrease in activation energy.

4,

(a) *Award **[2 max]** for three of the following features:*

Bonding

*Graphite **and** C_{60} fullerene:* covalent bonds **and** van der Waals'/London/dispersion forces;
Diamond: covalent bonds (and van der Waals'/London/dispersion forces);

Delocalized electrons

*Graphite **and** C_{60} fullerene:* delocalized electrons;
Diamond: no delocalized electrons;

Structure

Diamond: network/giant structure / macromolecular / three-dimensional structure **and** *Graphite:* layered structure / two-dimensional structure / planar;
C_{60} fullerene: consists of molecules / spheres made of atoms arranged in hexagons/pentagons;

Bond angles

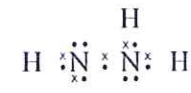
Graphite: 120° **and** *Diamond:* 109°;
C_{60} fullerene: bond angles between 109–120°;
*Allow Graphite: sp^2 **and** Diamond: sp^3.*
*Allow C_{60} fullerene: sp^2 **and** sp^3.*

Number of atoms each carbon is bonded to

*Graphite **and** C_{60} fullerene:* each C atom attached to 3 others;
Diamond: each C atom attached to 4 atoms / tetrahedral arrangement of C (atoms); ***[6 max]***

(b) (i) network/giant structure / macromolecular;
each Si bonded covalently to 4 oxygen atoms **and** each O atom bonded covalently to 2 Si atoms / single covalent bonds; *[2]*
*Award **[1 max]** for answers such as network-covalent, giant-covalent or macromolecular-covalent.*
Both M1 and M2 can be scored by a suitable diagram.

7. (a) (i)



; [1]

Accept x's, dots or lines for electron pairs

(ii) H–N–H < 109 / any angle between 104° and 109°;
due to four centres of electron/negative charge / four electron pairs (one of which is a lone e- pair) / four electron domains;
extra repulsion due to lone electron pairs; [3]
Do not allow ECF for wrong Lewis structures.

(b) weaker van der Waals'/London/dispersion/intermolecular forces in ethene;
stronger (intermolecular) hydrogen bonding in hydrazine; [2]
If no comparison between strengths then ***[1 max]***.

8.

(i) energy (per mole) needed to remove one/first/most loosely bound electron from a (neutral) atom;
in the gaseous state;
$Mg(g) \rightarrow Mg^{+}(g) + e^{-}$; [3]
Gaseous state symbols needed.
Accept e instead of e^{-}.
Only penalize omission of gas phase once in either the second marking point or the third marking point.

(ii) successive electrons (are more difficult to remove because each is) taken from more positively charged ion/ *OWTTE*;
increased electrostatic attraction; [2]

(iii) 10^{th} electron comes from 2^{nd} energy level/$n = 2$ **and** 11^{th} electron comes from 1^{st} first energy level/$n = 1$ / *OWTTE*;
electron in 1^{st} energy level closer to nucleus;
electron in 1^{st} energy level not shielded by inner electrons / exposed to greater effective nuclear charge; [3]